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(71) Applicant *(for all designated States except US)*: **NORTEL NETWORKS LIMITED** [CA/CA]; World Trade Center of Montreal, 380 St Antoine Street West, 8th Floor, Montreal, Quebec H2Y 3Y4 (CA).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **BRIDGER, Mark** [GB/GB]; 123 London Road, Hertford Heath, Hertfordshire SG13 7RH (GB). **GRANT, Michael, F.** [GB/GB]; 43 The Ridings, Bishop's Stortford, Hertfordshire CM23 4EJ (GB). **WILLIAMSON, Roger, J.** [GB/GB]; Abbeydale, Hadham Cross, Much Hadham, Hertfordshire SG10 6AL (GB). **TATE, Christopher, N.** [GB/GB]; 30 Cedar Park, Bishop's Stortford, Hertfordshire CM23 4JU (GB). **WALLACE, Andrew, D.** [GB/GB]; 119 Tickenhall Drive, Harlow, Essex CM17 9PF (GB). **FARRINGTON, Jeffrey, G.** [GB/GB]; 9 Lordswood View, Leaden Roding, Dunmow CM6 1SE (GB).

(74) Agent: **RYAN, J., P., W.**; Nortel Networks Limited, IP Law Group, London Road, Harlow, Essex CM17 9NA (GB).

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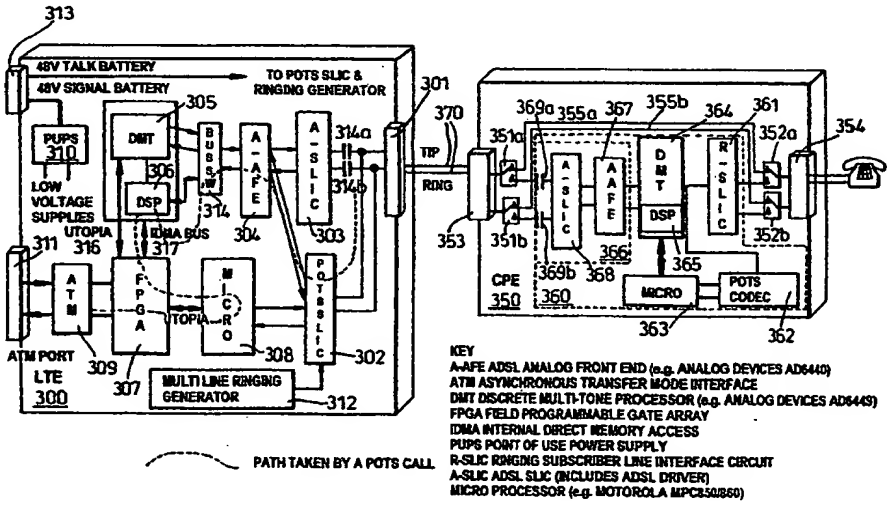
(54) Title: LIFELINE TELEPHONY PROVISION FOR VOICE OVER DIGITAL SUBSCRIBER LINE



(57) Abstract: A method, apparatus, and software for providing lifeline service during power failure affecting Customer Premises Equipment (CPE) in a Digital Subscriber Loop (DSL) arranged to carry voice traffic in band rather than on a separate analogue POTS band. The arrangement provides a reduced service, capable of supporting at least one voice call, to operate during such power failure and, where a single call is in progress during power failure, that call may be maintained during the transition from DSL to analogue POTS lifeline service. Where a call is in progress upon power restoration, the lifeline POTS service may be maintained until completion of the call so as not to interrupt a potential lifeline call.

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LIFELINE TELEPHONY PROVISION FOR VOICE OVER DIGITAL SUBSCRIBER LINE

FIELD OF THE INVENTION

The present invention relates to a method and apparatus for provision of lifeline telephony for a Voice over Digital Subscriber Line and a system incorporating the same.

BACKGROUND TO THE INVENTION

Digital Subscriber Line (DSL) modem technology has enabled the transmission of digital information at duplex rates from 144Kbits/s to greater than 1 Mbits/s over the subscriber loop. The demand for additional telephone lines and integrated telephony and data services has given rise to Voice over DSL (VoDSL) solutions. For example a VoDSL system may provide 4 voice channels carried within the digital data over a single twisted pair subscriber loop from a Line Terminating Equipment (LTE) located in the Central Office to a Customer Premises Equipment (CPE). In one implementation, a VoDSL system carries the voice channel(s) in band as encoded data within the data stream and therefore there is no baseband POTS (Plain Old Telephony Service) as would be the case with for example ADSL or G.Lite. Unlike normal telephony the derived voice method of VoDSL requires local power at the CPE to perform the modulation and demodulation.

Conventional analogue POTS telephony over a twisted pair to the LTE has the benefit that during power failure at the customer premises emergency calls can still be placed since the line and the handset at the customer premises are powered from the central office. A disadvantage of existing VoDSL modems is that the amount of power required for normal operation could severely limit the operational loop length if power is fed from the central office and thereby not provide a service able to reach the majority of consumers. This has limited deployment of VoDSL systems to subscribers having an additional conventional POTS line which can be used in the event of power failure. Absence of support for

transmitting voice from VoDSL to POTS. To provide lifeline service the LTE modem is automatically reconfigured from a VoDSL modem to a POTS subscriber line interface.

Advantageously, when the LTE re-establishes VoDSL capability with the CPE, the LTE is automatically reconfigured from a POTS Subscriber line interface to a VoDSL modem.

Advantageously, the LTE will interwork with any standard POTS device.

Advantageously, the LTE is capable of being reconfigured so as to emulate a POTS line card or an analogue or ISDN modem.

Advantageously, the CPE modem may be disconnected or removed and lifeline calls to be made by connection of a POTS device to the subscriber's port.

According to another aspect of the invention, there is provided a method of operating line terminating equipment for a voice-over digital subscriber loop comprising a subscriber loop port, and comprising the steps of:

sending and receiving digital subscriber loop signals via said subscriber loop port;

receiving an indication at said subscriber loop port of a change of operational mode of customer premises equipment connected to said subscriber loop port from a digital subscriber loop to analogue POTS loop;

operating said line termination equipment in an analogue POTS mode responsive to receipt of said indication.

The invention is also directed to a method by which the described apparatus operates and including method steps for carrying out every function of the apparatus.

According to another aspect of the invention, there is provided a line terminating equipment comprising a subscriber loop port and a network connection port; a voice-over digital subscriber loop modem circuit; and a direct electrical connection circuit; the equipment being arranged to operate in a first mode wherein a telecommunications connection is maintained between said subscriber loop port and said network

connection port via said voice-over digital subscriber loop modem, and in a second mode wherein a telecommunications connection is formed between said subscriber loop port and said network connection port via said direct electrical connection.

According to a further aspect of the invention, there is provided a customer premises equipment comprising a subscriber loop port and at least one local telephony port; a voice-over digital subscriber loop modem circuit; and a direct electrical connection circuit; the equipment being arranged to operate in a first mode wherein a telecommunications connection is maintained between said subscriber loop port and said at least one local telephony port via said voice-over digital subscriber loop modem, and in a second mode wherein a telecommunications connection is formed between said subscriber loop port and said local telephony port via said direct electrical connection

The invention also provides for a system for the purposes of digital signal processing which comprises one or more instances of apparatus embodying the present invention, together with other additional apparatus.

The preferred features may be combined as appropriate, as would be apparent to a skilled person, and may be combined with any of the aspects of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to show how the invention may be carried into effect, exemplary embodiments of the invention will now be described below by way of example only and with reference to the accompanying figures in which:

Figure 1 shows an example allocation of frequencies to analogue POTS, ISDN, and DSL according to the prior art;

Figure 2 shows an example allocation of frequencies to Voice over DSL in normal mode and to analogue POTS in lifeline mode according to the present invention;

Figure 3 shows a first example arrangement of CPE and LTE according to the present invention;

modem to act as a POTS Subscriber Line Interface and drives the line as a standard POTS line. (The precise method by which a CPE modem is placed into lifeline and the methods of signalling/detection of this mode are described below).

Referring now to Figure 3, there is shown a subscriber loop arrangement comprising LTE 300 at the central office and CPE 350 at a subscriber's premises. The CPE comprises a VoDSL modem 360, two pairs of switches 351a-b, 352a-b, a subscriber loop port 353, a local telephony port 354, and a pair of direct paths 355a-b between the two switches. The VoDSL modem and the direct paths are arranged in parallel between the switchable contacts of the two pairs of switches. The non-switchable contacts of the two pairs of switches are connected to the subscriber loop port and the local telephony port respectively. The switches are each arranged so that in normal operation the VoDSL modem is connected between the two ports 353, 354, whilst on a loss of local power to the equipment, both switches automatically revert to the position in which the direct paths are connected between the two ports. Relays would be appropriate switches to achieve this effect.

The VoDSL modem itself comprises ringing subscriber line interface circuit (R-SLIC) 361, POTS coder/decoder (POTS CODEC) 362, a processor 363 (for example Motorola MPC850/860 PowerPC™), Discrete MultiTone modem 364 (DMT) incorporating a Digital Signal Processing (DSP) 365 capability, an ADSL Analogue Front End 366 incorporating coder/decoder functions (A-AFE) 367, an ADSL subscriber line interface circuit (A-SLIC) 368 (including an ADSL driver), and a pair of high pass filters 369a-b (for example shown symbolically as a capacitor). The functional components listed above are connected in series in the order listed between the pair of switches connected to the local telephony port and the pair of switches connected to the subscriber loop port.

Turning now to the LTE 300 at the central office, this comprises a subscriber loop port 301 , a POTS Subscriber line interface circuit (SLIC) 302, and in parallel an A- SLIC 303 (including an ADSL driver), an ADSL Analogue Front End 304, (A-AFE), a pair of high-pass filters 314a-b (shown symbolically as capacitors) in series with incorporating coder/decoder functions Discrete MultiTone modem (DMT) 305

incorporating a Digital Signal Processing (DSP) 306 capability, a Field Programmable Gate Array (FPGA) 307, a processor 308 (for example Motorola MPC850/860 PowerPc™), an asynchronous transfer mode (ATM) interface 309, a Point-of-Use Power Supply (PUPS) 310, an ATM port 311, a multi-line ringing generator 312, and an external power supply interface 313.

The subscriber loop port 353 of the CPE is connected to the subscriber loop port 301 of the LTE by a twisted copper pair 370 subscriber loop.

In normal operation as VoDSL modem the operational parts of the LTE are connected as follows.

The ATM port 311 is connected to the ATM interface 309 by means of a standard ATM physical layer interface such as ATM 25.6Mbits/s. The ATM interface connects to the FPGA 307 by means of a standard ATM parallel interface such as UTOPIA 316. The FPGA connects to the DMT modem 305 also by means of a UTOPIA interface. The DSP within the DMT modem logically connects to the microprocessor 308 by means of a parallel microprocessor bus (for example IDMA bus) 317, but physically signals are routed via the FPGA 308 to provide the necessary glue logic. The processor 307 is also connected to the FPGA by means of a UTOPIA interface. The DMT modem connects to the A-AFE 304 via separate receive and transmit data buses connected via digital bus switches 314. The AAFE connects to the A-SLIC by means of receive and transmit analogue differential pairs. The A-SLIC connects to the line 370 by means of a two wire differential pair via line interface 301 and the pair of high pass filters 314a-b.

In normal operation data and voice is carried within ATM cells, using the data ATM Adaption layer 5 (AAL5) and the voice using ATM adaption layer 2 (AAL2).

The ATM interface 309 provides a connection between the ATM 25.6 Mbits/s physical port and a parallel UTOPIA port on the FPGA.

The FPGA 307 provides the cell buffering necessary to adapt the rates of cell arrival and departure to the rate of transmission of those cells. It also provides glue logic.

The DSP also provides silence insertion, fax detect, AAL2 mini-cell generation, packing and unpacking voice samples into/from AAL2 mini cells.

In the receive direction the processor 308 takes AAL2 mini cells of encoded voice generated by the DSP 306 and packs them into ATM cells using an AAL2 Segmentation and Re-assembly function available on the processor. These ATM cells are output to the UTOPIA port.

In the transmit direction the processor 308 unpacks the AAL2 mini-cells from the ATM cells and outputs them via the IDMA bus 317 to the DSP 306. The processor also monitors the supervisory bits from the POTS SLIC 302 for off-hook detect. The processor terminates and generates POTS signalling messages as a proxy for the CPE 350. That is, signalling messages are generated and terminated by the processor as though they were generated and terminated by the CPE as would be the case in normal operation. The processor may also perform dialled digit collection. The processor is also responsible for configuring the POTS SLIC.

The DMT modem performs no function in lifeline mode and may be powered down.

The ringing generator generates a high voltage ringing tone as required that is used to ring the subscriber's telephone.

Operation of the arrangement as a whole is as follows.

The LTE VoDSL modem is connected to the CPE modem 360 over a subscriber loop 370. The LTE VoDSL modem is connected to the network by means of an ATM connection 311. Individual voice channels are carried as AAL2 mini-cells from the network over the VoDSL system to the CPE.

In this example the LTE modem detects that the CPE modem is no longer transmitting data and is therefore no longer VoDSL capable. This loss of VoDSL connection may be detected by a loss of detectable DSL signal at the LTE, or alternatively by receipt of an explicit "last gasp" loss of power signal generated by and received from the CPE. A further preferred signalling method is described below in more detail.

To ensure that reliable operation of DSL service, it is necessary to prevent non-ohmic contacts forming at joints in the loop and distorting the signal. This is achieved by supplying some sealing current of about 1-2mA by applying a voltage on the line at the Central Office. To create a sealing current, there needs to be some form of DC sink at the CPE. By placing this at the input to the CPE modem, it will be behind the switching used to re-route the line through to the telephone on lifeline mode. Thus, when the power goes down at the CPE and the switch changes over to the lifeline position, the sealing current will cease. This is detected at the LTE 300 at the Central Office, in the same way that off-hook is detected and it too goes into lifeline mode. The voltage supplied for sealing becomes the line battery voltage for POTS. When a telephone goes "off hook", the current drawn by the terminal is detected by the Central Office equipment in the usual way. This current will typically be greater than 20mA and so is distinguishable from the sealing current. Thus when the CPE modem has power restored, the switches will be activated to connect the line to the modem and the current drawn will return to about 1-2mA. Detection at the Central Office will indicate that the CPE modem has restored power, so it will in turn switch back to DSL mode.

Referring now to Figure 5 there is shown a further example of a system in accordance with the present invention. The arrangement comprises a CPE arrangement 350 identical to that shown in Figure 4, together with a modified LTE 300a which differs from the LTE arrangements 300 of Figures 3 and 4 in that the A-SLIC 303, POTS SLIC 302, high pass filters 314a-b are replaced by a circuit comprising a high voltage broadband subscriber line interface circuit (HVB-SLIC) and a pair of high pass filters 316a-b. In this arrangement the HVB-SLIC performs all of the necessary functions performed by the A-SLIC and POTS SLIC in the earlier embodiments, digitally synthesising the analogue output of the POTS SLIC to the subscriber loop port 301. This arrangement has the advantage of not requiring a separate POTS SLIC at the expense of the additional processing required to generate the synthesised analogue signal.

Whilst the CPE arrangement 350a is shown comprising a DC current sink 356 for signalling power loss to the LTE 300a, the LTE 300a comprising

CLAIMS

1. A method of operating customer premises equipment for a voice over digital subscriber loop (VoDSL) system comprising at least one local telephony port and a subscriber loop port, the method comprising the steps of:

connecting said at least one local telephony port directly to said subscriber loop port responsive to detection of a customer premises equipment power supply failure;

whereby to enable direct communication between said at least one local telephony port and said subscriber loop port so as to maintain at least a voice service to the customer.

2. A method according to claim 1 additionally comprising the steps of:

providing an indication at said subscriber loop port responsive to said detecting a power failure;

whereby to communicate with local exchange equipment connected to said subscriber loop port.

3. A method according to claim 1 wherein the step of providing an indication comprises:

effecting a change in a sealing current associated with said subscriber loop port.

4. A method of operating line terminating equipment for a voice-over digital subscriber loop comprising a subscriber loop port, and comprising the steps of:

sending and receiving digital subscriber loop signals via said subscriber loop port;

receiving an indication at said subscriber loop port of a change of operational mode of customer premises equipment connected to said subscriber loop port from a digital subscriber loop to analogue POTS loop;

operating said line termination equipment in an analogue POTS mode responsive to receipt of said indication.

5. A method as claimed in claim 4, and including maintaining a POTS call currently in progress on restoration of power.

6. A method as claimed in claim 5, wherein detection of a POTS call currently in progress is determined by measurement of the line voltage.

7. A method as claimed in claim 4, and wherein said line termination equipment is reconfigured so as to function as a POTS line card.

8. A method as claimed in claim 4, wherein said line termination equipment is reconfigured so as to function as an analogue modem or an ISDN modem.

9. A customer premises equipment comprising a subscriber loop port and at least one local telephony port; a voice-over digital subscriber loop modem circuit; and a direct electrical connection circuit; the equipment being arranged to operate in a first mode wherein a telecommunications connection is maintained between said subscriber loop port and said at least one local telephony port via said voice-over digital subscriber loop modem, and in a second mode wherein a telecommunications connection is formed between said subscriber loop port and said local telephony port via said direct electrical connection.

10. A customer premises equipment arrangement according to claim 7 wherein a transition from said first mode to said second mode is effected responsive to detection of a loss of electrical power to said customer premises equipment.

11. A customer premises equipment arrangement according to claim 8 wherein on transition from said first mode to said second mode an indication of said transition is presented at said subscriber loop port.

12. A customer premises equipment arrangement according to claim 9 wherein said indication is a change in sealing current.

13. A customer premises equipment according to claim 10 wherein substantially no sealing current is drawn in said second mode.

14. A customer premises equipment arrangement according to claim 11 wherein said indication is a digital signal.

15. A line terminating equipment comprising a subscriber loop port and a network connection port; a voice-over digital subscriber loop modem circuit; and a direct electrical connection circuit; the equipment being arranged to operate in a first mode wherein a telecommunications connection is maintained between said subscriber loop port and said network connection port via said voice-over digital subscriber loop modem, and in a second mode wherein a telecommunications connection is formed between said subscriber loop port and said network connection port via said direct electrical connection.

16. A line termination equipment arrangement according to claim 15, wherein a transition from said first mode to said second mode is effected responsive to receipt at said subscriber loop port of a signal indicative of power loss at equipment connected to said subscriber loop port.

17. A line termination equipment arrangement according to claim 15, wherein a transition from said second mode of operation to said first mode of operation is effected responsive to detection of power restoration.

18. A line termination equipment arrangement according to claim 15, wherein said transition from said second mode of operation to said first mode of operation is delayed responsive to detection of a call in progress in said second mode of operation during said power restoration.

19. A line termination equipment arrangement according to claim 15, wherein the equipment is reconfigurable so as to emulate a POTS line card.

20. A line termination equipment arrangement according to claim 15, wherein the equipment is reconfigurable so as to emulate an analogue modem or an ISDN modem.

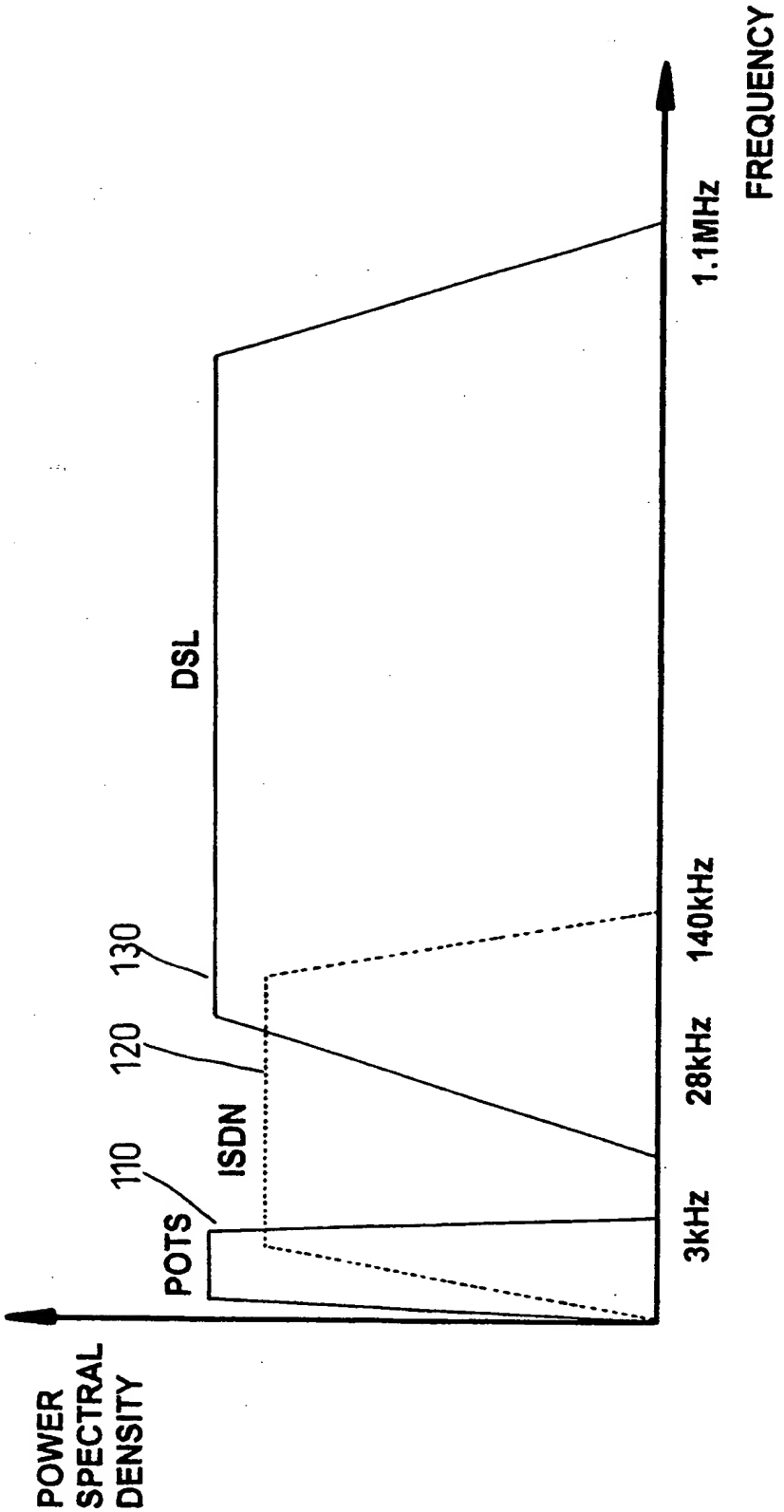
POWER SPECTRAL DENSITY
FREQUENCY
1.1MHz
140kHz
28kHz
3kHz
DSL
ISDN
POTS
130
120
110

Fig. 1

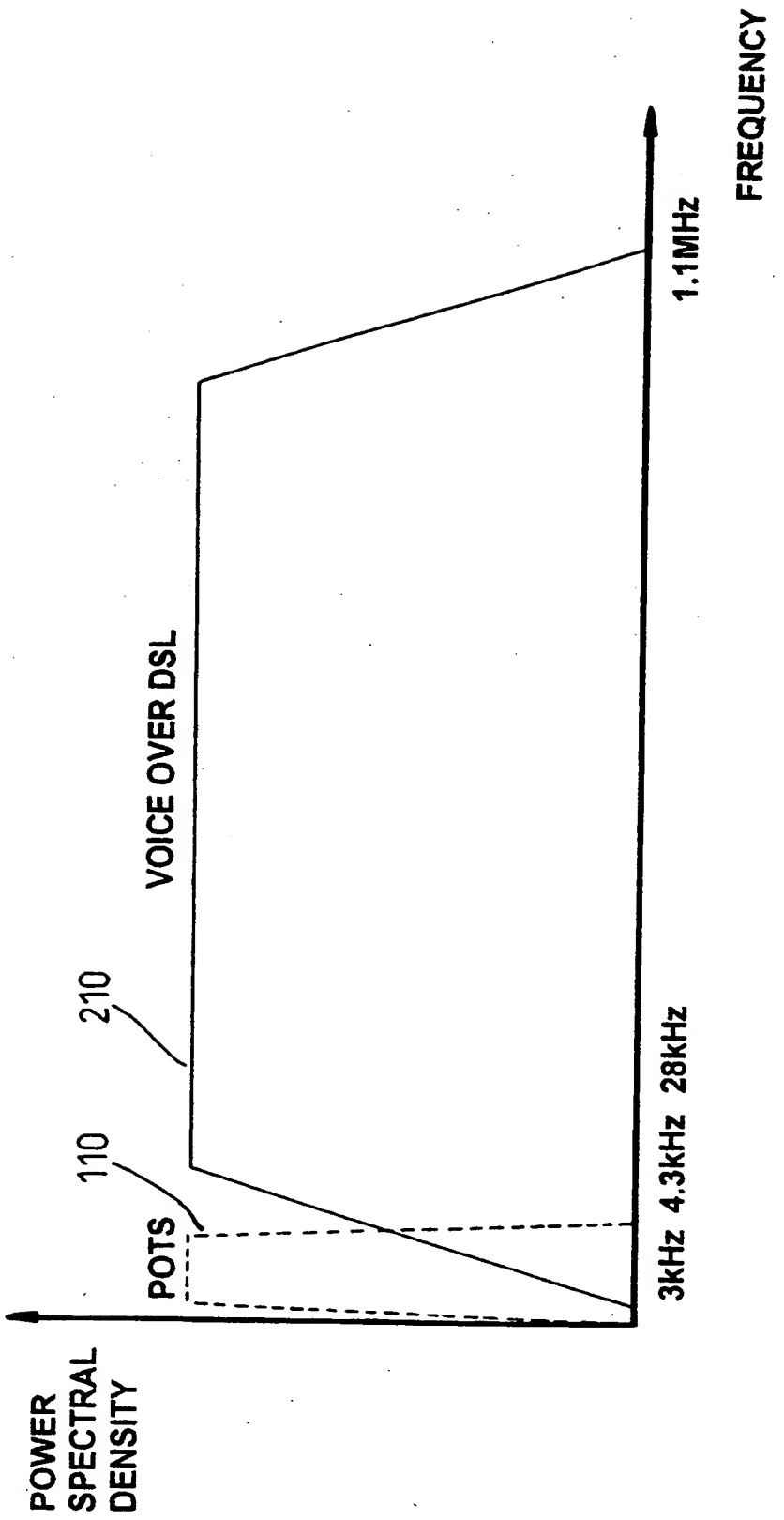

Fig. 2

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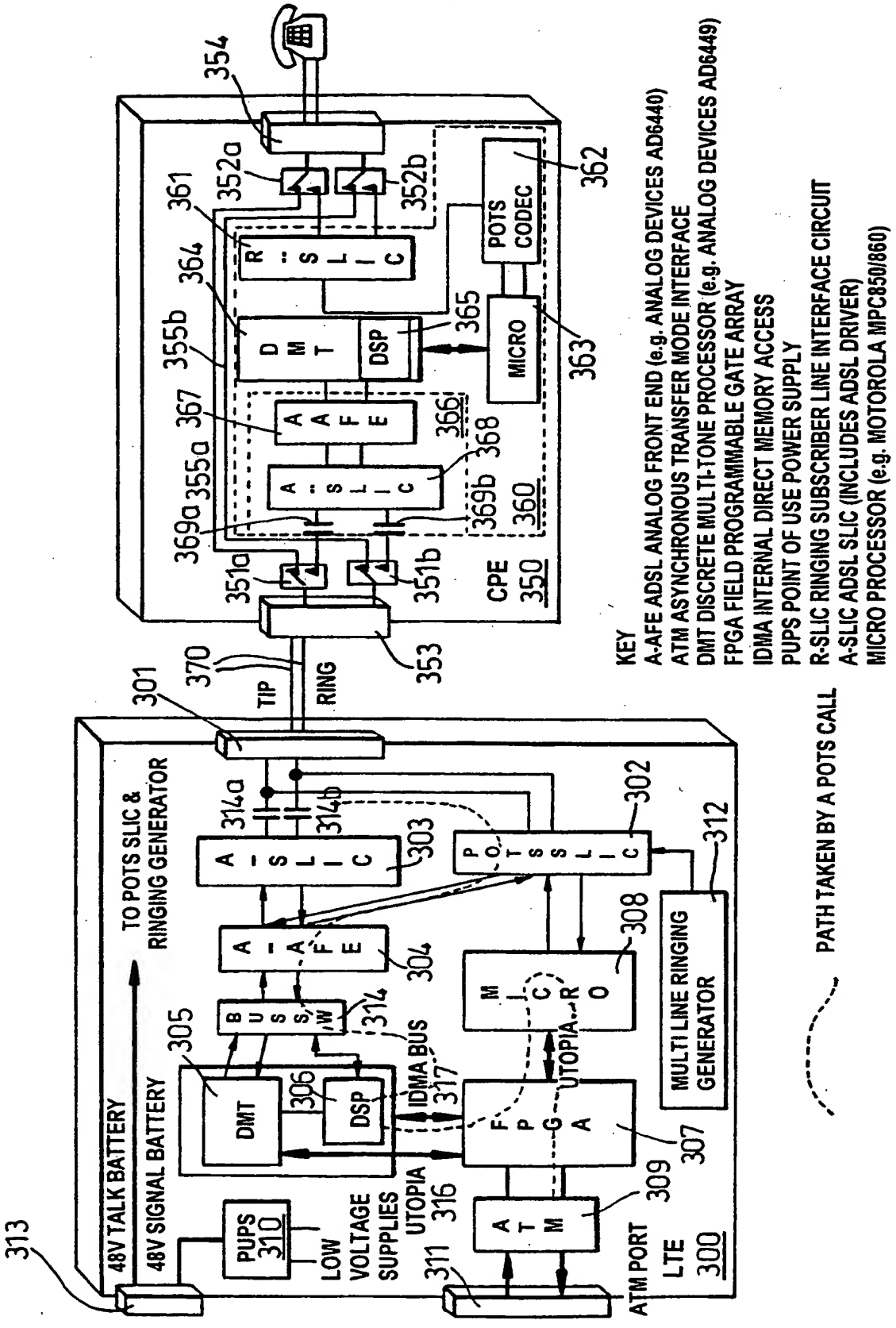
KEY
A-AFE ADSL ANALOG FRONT END (e.g. ANALOG DEVICES AD6440)
ATM ASYNCHRONOUS TRANSFER MODE INTERFACE
DMT DISCRETE MULTI-TONE PROCESSOR (e.g. ANALOG DEVICES AD6449)
FPGA FIELD PROGRAMMABLE GATE ARRAY
IDMA INTERNAL DIRECT MEMORY ACCESS
PUPS POINT OF USE POWER SUPPLY
R-SLIC RINGING SUBSCRIBER LINE INTERFACE CIRCUIT
A-SLIC ADSL SLIC (INCLUDES ADSL DRIVER)
MICRO PROCESSOR (e.g. MOTOROLA MPC850/860)
PATH TAKEN BY A POTS CALL
CPE 350
LTE 300
ATM PORT
TO POTS SLIC & RINGING GENERATOR
48V TALK BATTERY
48V SIGNAL BATTERY
LOW VOLTAGE SUPPLIES
PUPS 310
DMT
DSP
IDMA BUS
UTOPIA
FPGA
MICRO
MULTI LINE RINGING GENERATOR
POTS CODEC
TIP
RING
313
301
370
354
352a
352b
361
362
364
365
355b
363
367
366
368
355a
369a
369b
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Fig. 3

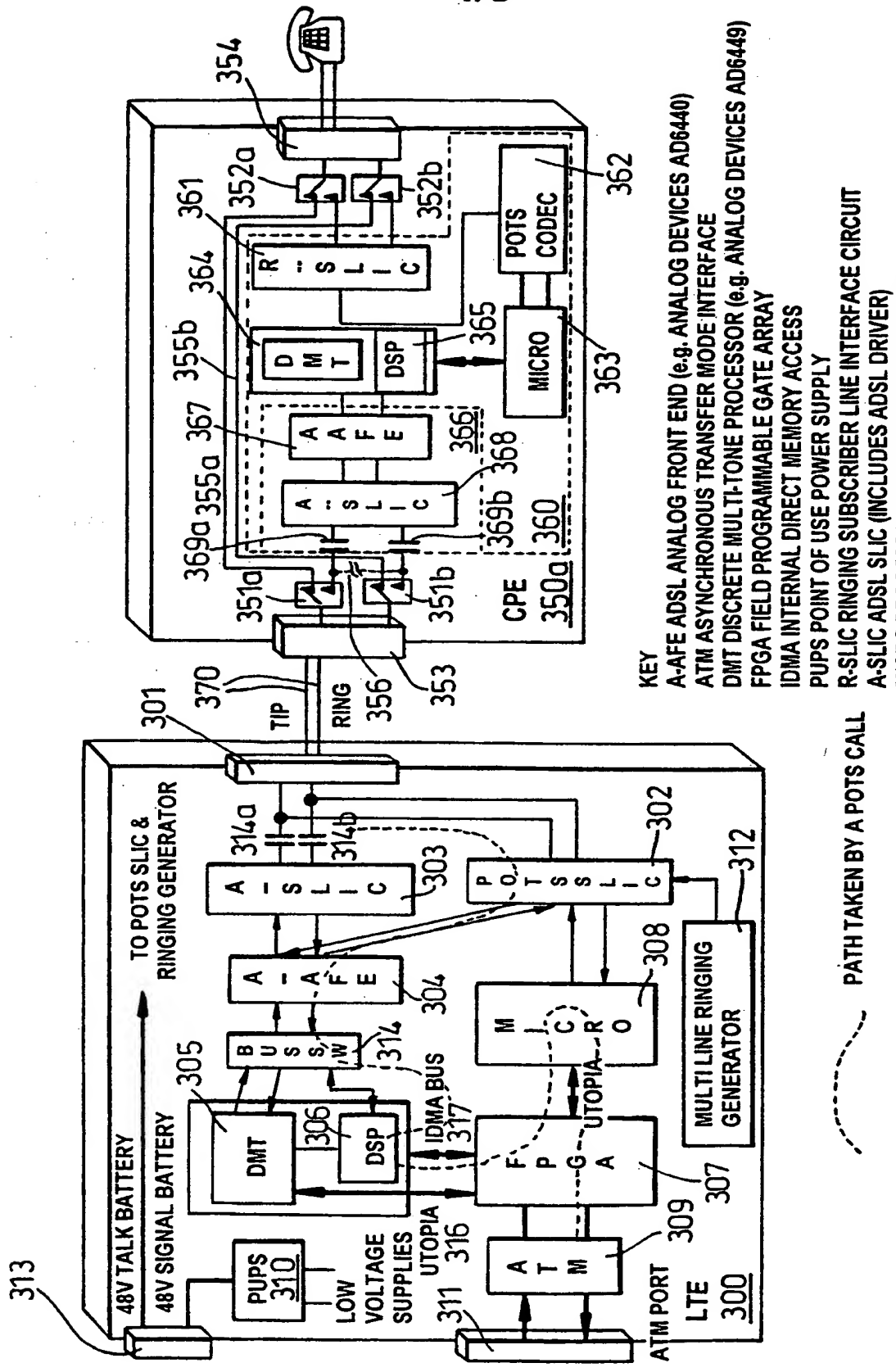

Fig. 4

INTERNATIONAL SEARCH REPORT

rnational Application No
PCT/GB 00/03150

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L12/64

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 313 979 A (PLESSEY TELECOMM) 10 December 1997 (1997-12-10) page 3, line 8 - line 20	1,2,4,5, 9,15
A	US 5 883 941 A (AKERS FRANCIS I) 16 March 1999 (1999-03-16) column 3, line 18 - line 46 column 4, line 58 - line 67	1-9, 11-20

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
5 December 2000	13/12/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Gregori, S

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 00/03150

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2313979 A	10-12-1997	AU 3039797 A	05-01-1998
		CN 1195453 A	07-10-1998
		EP 0843948 A	27-05-1998
		WO 9747157 A	11-12-1997
		JP 11510985 T	21-09-1999
		NO 980503 A	06-04-1998
US 5883941 A	16-03-1999	AU 6480198 A	29-05-1998
		EP 0931410 A	28-07-1999
		WO 9820669 A	14-05-1998

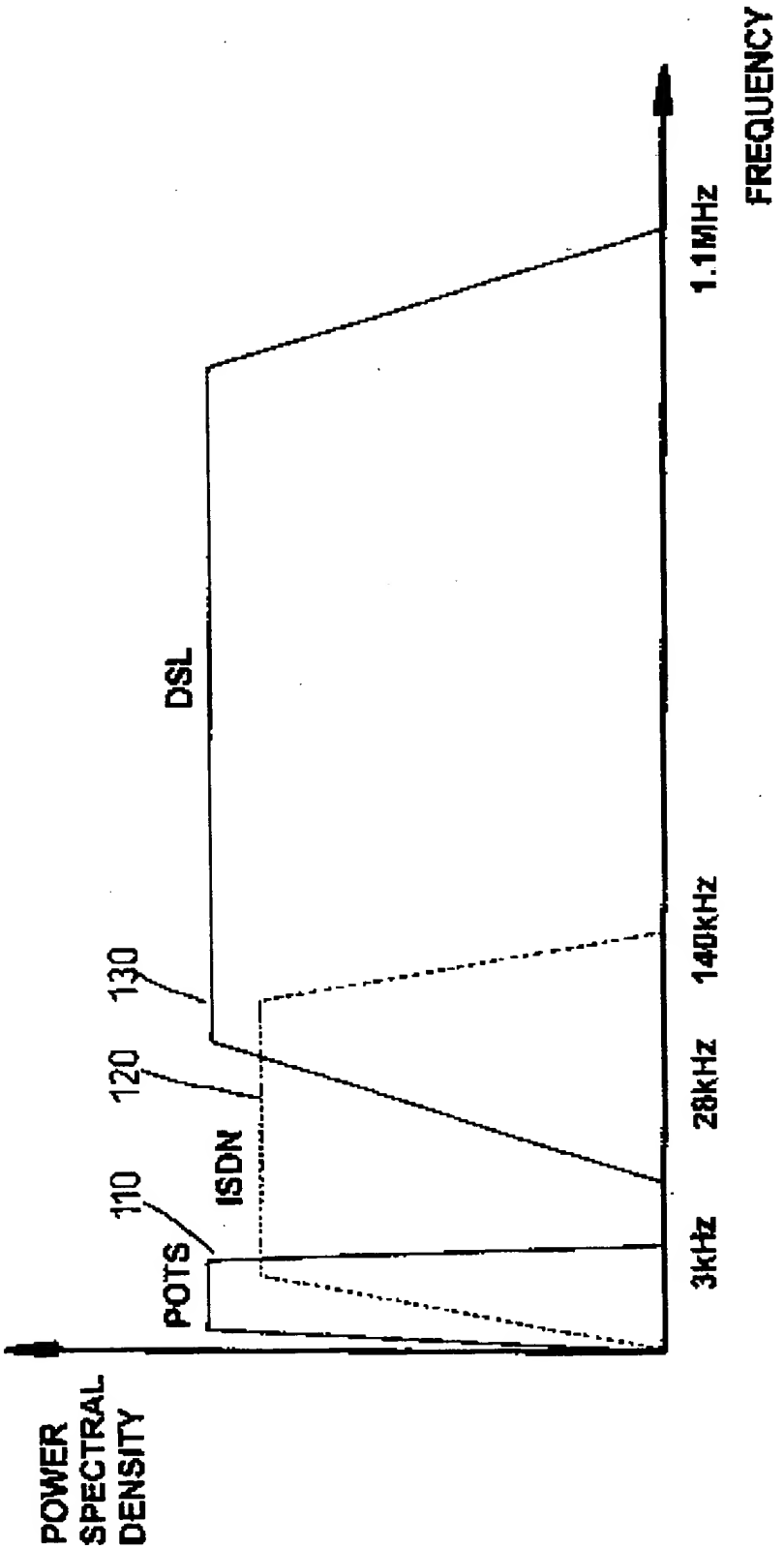

Fig. 1

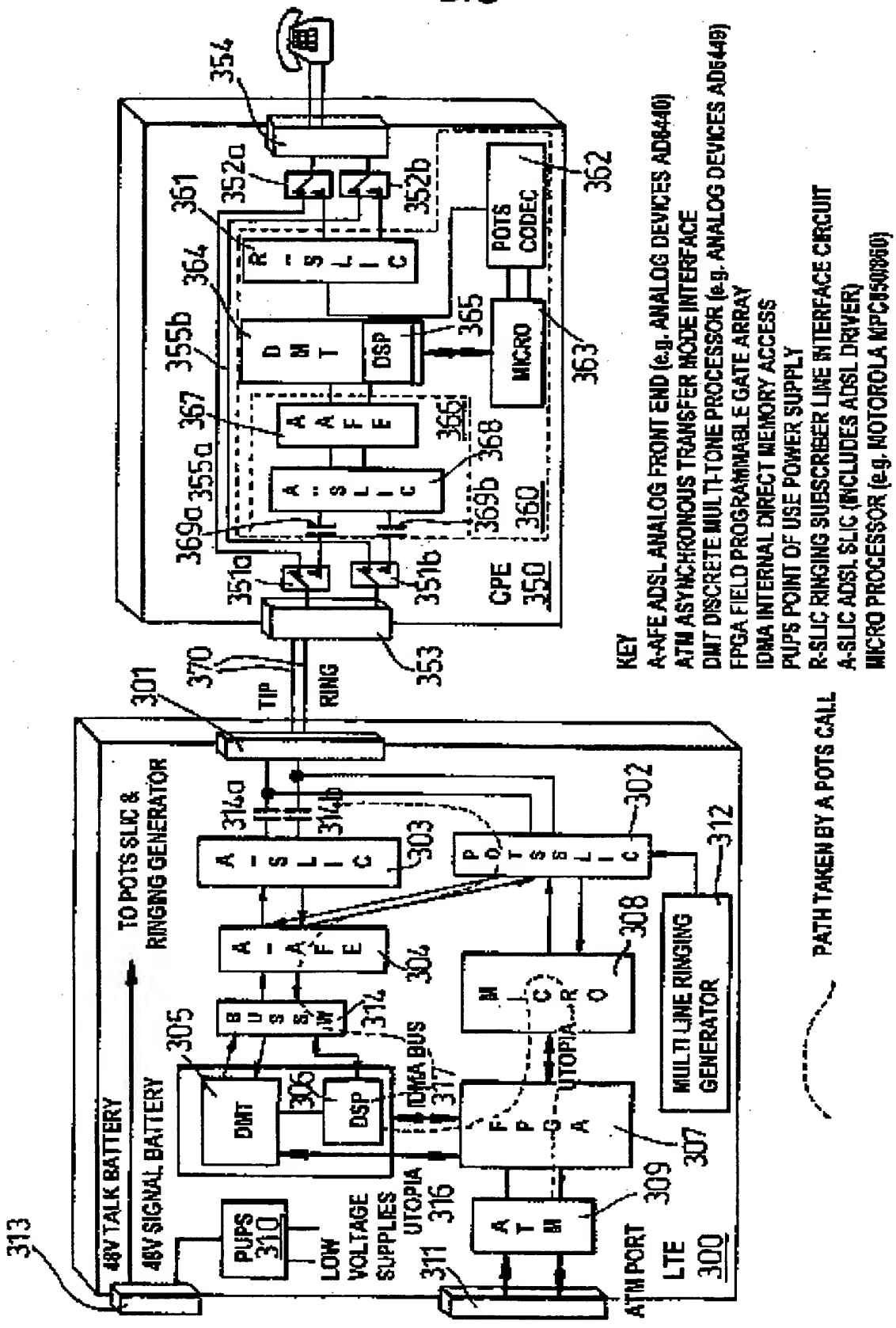

Fig. 3

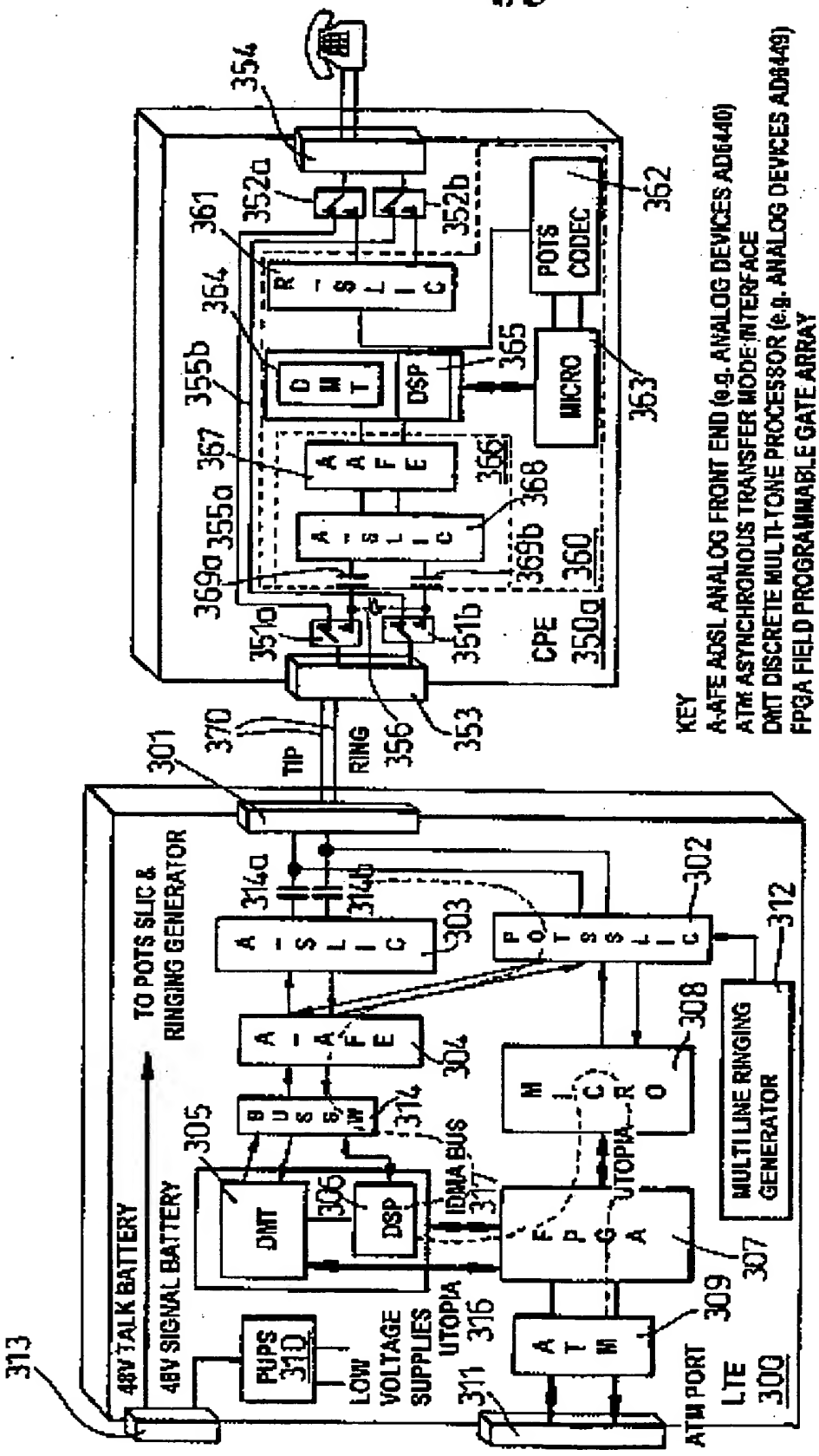

Fig. 4

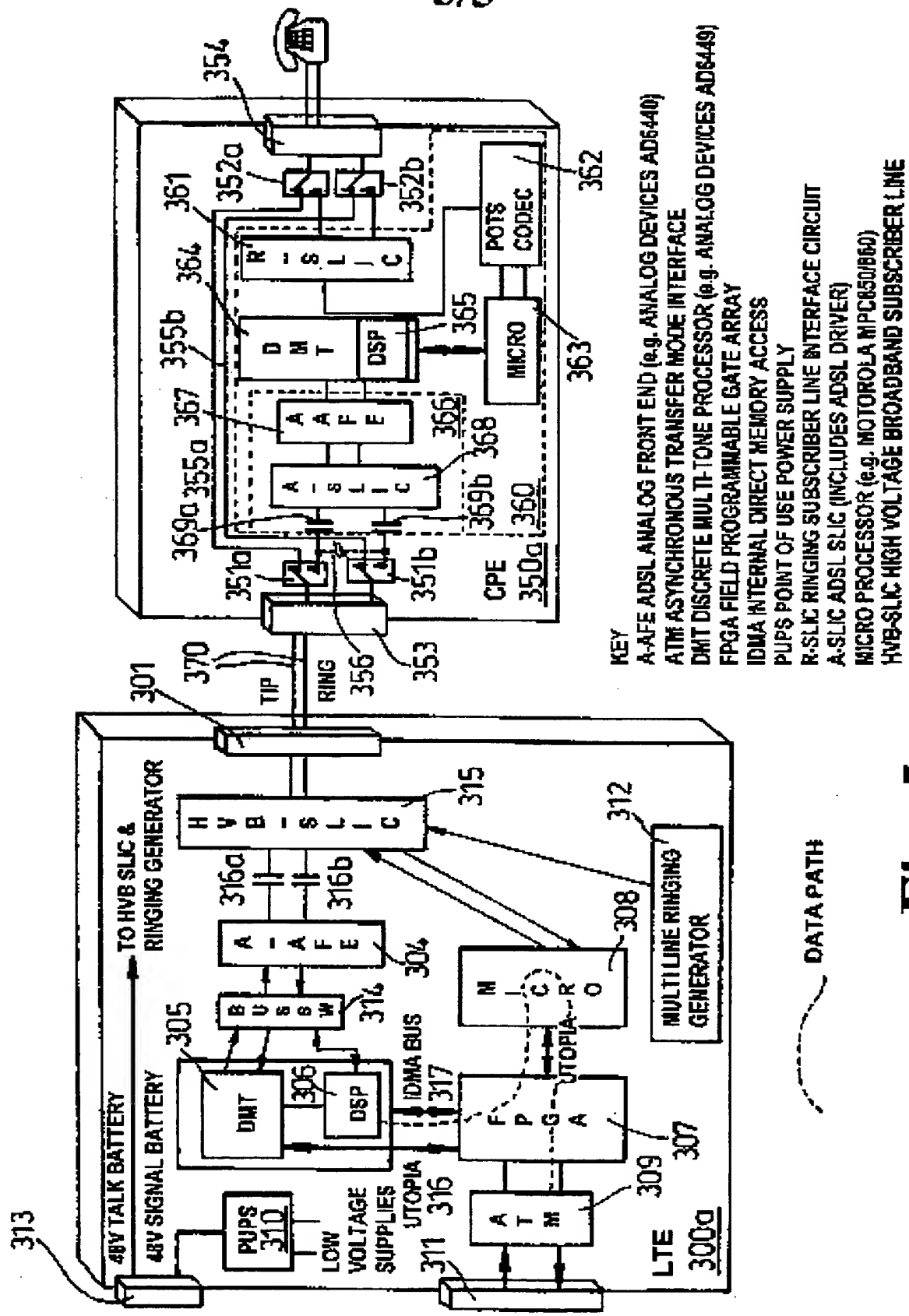

Fig. 5